

INSTRUCTION MANUAL
MODEL 147
HF SWEEP GENERATOR

WAVETEK

9045 BALBOA AVENUE, SAN DIEGO, CALIFORNIA



Serial No. _____

INSTRUCTION MANUAL
MODEL 147
HF SWEEP GENERATOR

WAVETEK
Box 651, San Diego, Calif., 714-279-2200

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Figure i — Model 147 HF Sweep Generator

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SECTION

INTRODUCTION

1.1 PURPOSE OF THE EQUIPMENT

The Model 147 HF Sweep Generator is a precision 0.0005 Hz to 10 MHz source of sine, triangle, square, positive pulse, and negative pulse waveforms, each with variable amplitude, dc offset, and symmetry. Frequency range selection is provided in 10 decades, with a 3½ digit LED readout and vernier control which permits accurate adjustment of the least significant digit of the readout. The 3½ digit readout is 3 digits plus a fourth (the most significant) digit of 0 or 1. DC voltage output is also selectable with an adjustable range of ± 10 Vdc into an open circuit (± 5 Vdc into 50Ω) with up to 150 mA.

Maximum output amplitude is 30 V p-p into an open circuit (15 V p-p into 50Ω) with a 60 dB calibrated step attenuator and a 20 dB vernier attenuator (80 dB overall) allowing signal levels as low as 1.5 mV p-p. Both the output waveform and the dc offset are attenuated by the 60 dB calibrated step attenuator. Maximum and minimum output peak voltages are displayed on the 3½ digit LED readout and are accurate when the output has been properly terminated with 50Ω .

The Model 147 has six operational modes (continuous, triggered, gated, continuous sweep, triggered sweep, and sweep and hold) plus tone burst capability. The main output can be internally swept over approximately a 1000:1 ratio at sweep times from 10 μ s to 100 seconds, or it can be frequency modulated, dc programmed, or externally swept over a greater than 1000:1 ratio by applying an external control signal to the front panel VCG IN connector. A single cycle of output, or one full sweep of the output, can be obtained by manual trigger or an external trigger signal applied to the front panel TRIG IN connector.

In addition to the 50Ω main output and sync output, the Model 147 also has sweep and generator control voltage (GCV) outputs. When the main output is not internally swept (i.e., operating in continuous, triggered, or gated modes without sweeping), the fixed amplitude sawtooth output of the internal sweep generator appears at the SWP/GCV connector. When the main output is internally swept, an output voltage proportional to the instantaneous frequency of the main generator will appear at the SWP/GCV connector. This GCV output can be used to drive X-Y

recorders or the vertical and horizontal deflection circuits of oscilloscopes, video monitors, etc.

Varying the triangle symmetry produces a sawtooth signal with a rise or fall time as fast as 50 nanoseconds at a recurring rate of up to 1 MHz. Pulse outputs as narrow as 50 nanoseconds (duty cycles from 19:1 to 1:19) with repetition rates as high as 1 MHz can be generated in either polarity. Even the sine wave symmetry may be varied over this 1:19 to 19:1 range if desired. When the output symmetry is not 1:1, the frequency range setting is divided by approximately 10; however, the actual output frequency is displayed on the LED readout.

With this instrument it is possible to internally or externally sweep the output frequency, select the output symmetry desired, and manually vary the dc offset. The output frequency, positive peak amplitude and negative peak amplitude are displayed on a digital readout. DC offset or dc output voltage can be set by digital readout. These capabilities coupled with the variety of waveforms available and precision output amplitude control make the Model 147 an extremely versatile instrument.

1.2 GENERAL PHYSICAL DESCRIPTION

The Model 147 weighs approximately 12 lbs (5.4 kgs) net and 16 lbs (7.26 kgs) when shipped. It is 14½ in. (368 mm) wide, 5¼ in. (133 mm) high, and 14¼ in. (362 mm) deep, and is housed in a compact, ruggedized, portable case. The Model 147 is normally shipped with a 10 foot, 3 wire, detachable line cord and one copy of this instruction manual.

1.3 SPECIFICATIONS

1.3.1 Waveforms

Waveforms that may be selected are sine , square , triangle , positive pulse  and negative pulse . DC voltage may also be selected. Symmetry of all outputs are continuously adjustable from 1:19 to 19:1. Varying the triangle symmetry produces sawtooth  or  output. The Model 147 has a SWP/GCV OUTput and a SYNC OUTput with variable symmetry as described below. Signal frequency and maximum and minimum peak signal voltages are indicated by a 3½ digit LED readout.

1.3.2 Operating Frequency Range

The FREQUENCY RANGE (Hz) switch selects from 0.0005 Hz to 10 MHz in the following ranges:

0.01	0.0005 Hz to 0.01 Hz
0.1	0.005 Hz to 0.1 Hz
1	0.05 Hz to 1 Hz
10	0.1 Hz to 10 Hz
100	1 Hz to 100 Hz
1K	10 Hz to 1 kHz
10K	100 Hz to 10 kHz
100K	1 kHz to 100 kHz
1M	10 kHz to 1 MHz
10M	100 kHz to 10 MHz

The FREQUENCY CONTROL adjusts the frequency to the least significant digit of the readout.

1.3.3 Main Output

The 50Ω OUT is the output for the selectable waveform and dc output. Maximum output is 30 V p-p into an open circuit; 15 V p-p into 50Ω. There is a precision output attenuator calibrated in 20 dB steps to -60 dB with an overlapping vernier for an overall attenuation of -80 dB. Output impedance is 50Ω. Short circuit current is 150 mA.

1.3.4 Sync Output

The SYNC OUT connector provides greater than 4 V p-p into an open circuit; 2 V p-p into 50Ω. Rise and fall times are less than 50 ns. The sync signal is a square waveform for symmetrical outputs and rectangular for asymmetrical outputs. Sync pulse polarity is 180° out of phase with the selectable output square wave and 90° out of phase with the sine and triangle waveforms.

1.3.5 DC Offset and DC Output

DC offset and dc output are controlled manually by a front panel control. The adjustable range is ±10 Vdc into an open circuit (±5 Vdc into 50Ω) with peak signal and offset amplitude limited to ±15 Vdc into an open circuit (±7.5 Vdc into 50Ω). DC offset and output waveform are attenuated proportionately by the 60 dB step output attenuator.

1.3.6 Sweep/GCV Output

Sweep output is a 0 to nominal +5 V sawtooth when in continuous, triggered or gated mode, and runs at a frequency determined by the SWEEP TIME control. GCV output is a 0 to nominal +5 V signal proportional to the instantaneous frequency output. This GCV signal is present when the Model 147 is in any of the sweep modes.

1.3.7 Operational Modes

Continuous (CONT)

The Model 147 operates as a standard VCG (Voltage Controlled Generator). Frequency at the 50Ω OUT connector is determined by front panel control settings in conjunction with the VCG input signal. Output of the internal sweep generator appears at the SWP/GCV OUT connector in this mode.

Triggered (TRIG)

Only one complete cycle of output appears at the 50Ω OUT connector for each pulse applied to the TRIG IN connector or push of the manual trigger. The cycle begins and ends at zero phase angle, which is zero volts or the offset base line voltage level. At least 1 V peak (and up to 50 V peak) is required for the trigger signal. TRIG IN is 10 kΩ, dc coupled.

GATED

Gated mode is the same as triggered mode except that output oscillations continue for the duration of the gating signal applied to the TRIG IN connector or push of the manual trigger. The output will be an integral number of cycles beginning and ending at zero phase angle, which is zero volts or the offset base line voltage level.

Continuous Sweep (CONT SWP)

In continuous sweep, the main generator is swept by the internal sweep generator so that the signal frequency at the 50Ω OUT connector is swept from a low frequency established by the front panel frequency controls to a high frequency determined by the SWEEP WIDTH control setting. Sweep width can be up to approximately 1000:1. Sweep rate, determined by the SWEEP TIME control, is 10 μs to 100 s. GCV appears at the SWP/GCV connector.

Triggered Sweep (TRIG SWP)

Triggered sweep is the same as continuous sweep mode except that the output is swept only once for each pulse applied to the TRIG IN connector. During the time between sweeps, the main generator oscillates at a frequency determined by the FREQUENCY CONTROL settings.

Sweep and Hold (SWP & HOLD)

In this mode, a gate signal at the TRIG IN connector causes the Model 147 to begin a frequency sweep. After sweeping to the top frequency, the output holds at the top frequency as long as the gate signal is present. When the gate signal drops, the output returns to the frequency set by the front panel frequency controls.

Tone Burst

A tone burst can be accomplished in GATED mode by connecting the ramp output of SWP/GCV OUT to TRIG IN. Tone burst rate, frequency and duration can be independently controlled.

1.3.8 Voltage Controlled Generator

VCG Control Range

The generator frequency can be controlled by an external voltage; e.g., five volts can vary the frequency 1000:1. Restrictions for linear operation are: FREQUENCY RANGE selection is the upper frequency and the lower frequency is 1000 times below the FREQUENCY RANGE selection; ± 5 V is the maximum voltage input. Either restriction may be exceeded for nonlinear operation, but operation is not specified. Input impedance is 5 k Ω .

VCG Input Frequency

VCG Bandwidth 100 kHz
VCG Slew Rate 2% of range per μ s

VCG Linearity

10 Hz to 100 kHz $\pm 0.2\%$
0.001 Hz to 1 MHz $\pm 0.5\%$

1.3.9 Horizontal Precision

Frequency Readout Accuracy

10 kHz to 10 MHz $\pm(0.2\%$ of range ± 1 digit)
0.01 Hz to 10 MHz $\pm(0.3\%$ of range ± 1 digit)

Time Symmetry

10 Hz to 100 kHz $\pm 0.5\%$
0.01 Hz to 500 kHz $\pm 1.0\%$

1.3.10 Vertical Precision

Amplitude Readout Accuracy

1 Hz to 10 MHz $\pm(5\%$ of full output ± 1 digit)
1 Hz to 100 kHz $\pm(3\%$ of full output ± 1 digit)

NOTE

The display voltage is 50 Ω terminated voltage. For operation in the 0.01 Hz or 0.1 Hz range, amplitude display is the instantaneous voltage value in a tracking mode. Readout update is three times a second.

Sine Wave Frequency Response

Amplitude change with frequency is less than:
0.1 dB to 100 kHz
0.2 dB to 1 MHz
2.0 dB to 10 MHz

Step Attenuator Accuracy

± 0.25 dB per 20 dB step

Stability

Short Term $\pm 0.05\%$ for 10 minutes
Long Term $\pm 0.25\%$ for 24 hours
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry

All waveforms (except pulse) are symmetrical about ground within $\pm 1\%$ of maximum peak to peak amplitude.

1.3.11 Purity

Sine Wave Distortion

10 Hz to 100 kHz Less than 0.5% (typically 0.25%)
100 kHz to 1 MHz Less than 1.0%
1 MHz to 10 MHz .All harmonics are at least 30 dB down

Triangle Linearity

0.0005 Hz to 100 kHz Greater than 99%

Square Wave Rise and Fall Time

Less than 30 ns when terminated by 50 Ω .

Total Aberrations

Less than 5%.

1.3.12 Environmental

Temperature

All specifications listed, except for stability, are for 25 $^{\circ}$ C $\pm 5^{\circ}$ C. For operation from 0 $^{\circ}$ C to 55 $^{\circ}$ C, derate all specifications by a factor of 2.

1.3.13 Mechanical

Dimensions

14 $\frac{1}{2}$ in. (368 mm) wide; 5 $\frac{1}{4}$ in. (133 mm) high; 14 $\frac{1}{4}$ in. (362 mm) deep.

Weight

12 lbs (5.45 kgs) net; 16 lbs (7.26 kgs) shipping.

Power

90 to 110 V, 105 to 125 V, 180 to 220 V or 210 to 250 V;
50 to 400 Hz switchable; less than 50 watts.

INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to knobs, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit.

NOTE

Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 105 - 125 Vac line supply and with a one amp, 115 V line fuse.

Conversion for 90 to 110 V, 180 to 220 V or 210 to 250 V operation requires resetting two switches on the inside of the rear panel. To reset the switches, unscrew the two captive screws securing the rear panel, and remove the rear panel. Set the two switches and select the fuse for the ac line voltage according to the following table.

AC Line Voltage	Switch A	Switch B	Fuse (SB)
90 - 110	115	LO	½ amp/115 V
105 - 125	115	HI	½ amp/115 V
180 - 220	230	LO	¼ amp/230 V
210 - 250	230	HI	¼ amp/230 V

2.2.2 Signal Connections

Use 50Ω shielded cables equipped with female BNC connectors to distribute all RF signals when connecting this instrument to associated equipment.

2.3 OPERATING CONTROLS

The operating controls and electrical connections for the Model 147 are shown in Figure 2-1. The listing below discusses each control and its function.

- POWER Switch** — Power is on when this push button switch is in, and off when extended.
- READOUT FUNCTION FREQ Push Button** — When this push button is depressed, it causes the signal frequency at the 50Ω output to be displayed.
- READOUT FUNCTION PK AMPL, MAX/MIN Push Buttons** — MAX push button, when depressed, causes the maximum peak signal voltage to be displayed; MIN causes the minimum peak voltage to be displayed.
- Display and Readout Functions** — A fully automatic, direct reading display of the generator frequency and peak voltage outputs. When PK AMPL MAX or MIN push button is depressed, maximum or minimum peak voltage, respectively, is displayed. When the FREQ push button is depressed, the frequency is displayed. This is a 3½ digit display with sign, decimal point, and unit of measure. The decimal point is automatically positioned and the correct unit of measure automatically displayed. The three least significant digits each can be 0 through 9 while a fourth digit, the most significant digit, can be 0 or 1 only. All readings are updated three times a second.

NOTE

- Display voltage is output voltage when the 50Ω output connector is properly terminated with a 50Ω load.
- The peak voltage reading circuits for each frequency range are most accurate when the generator is operated at the high end of the frequency range selected.
- For operation in the 0.01 Hz or 0.1 Hz range, amplitude display is instantaneous voltage

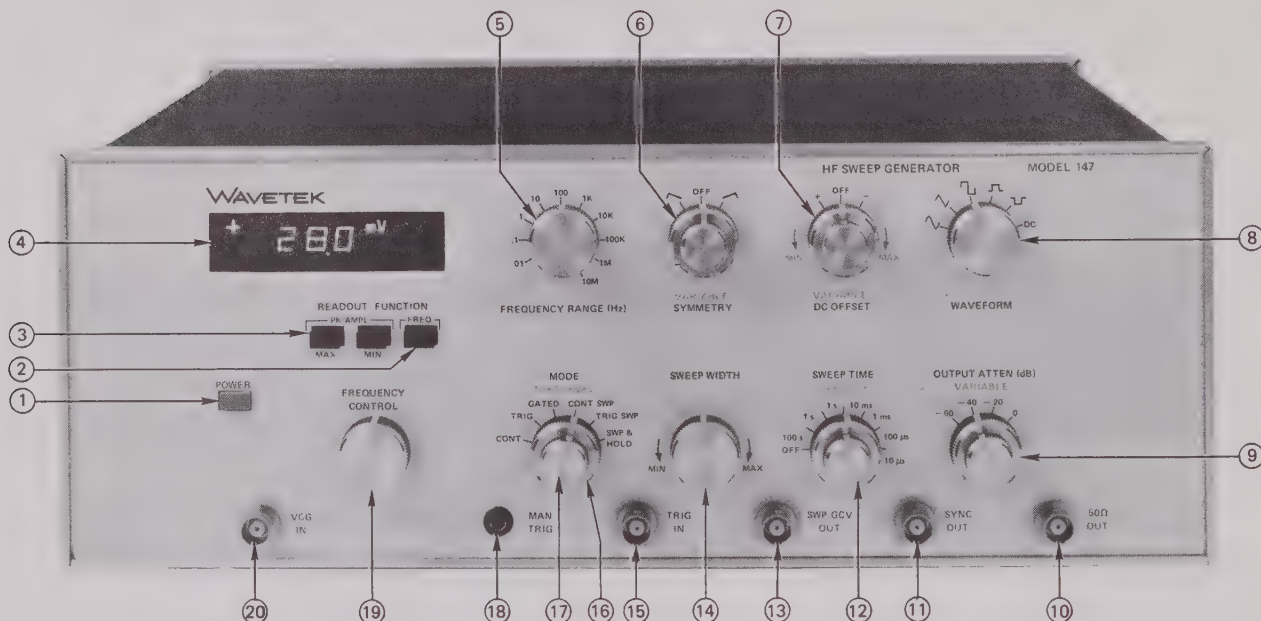


Figure 2-1. Operating Controls

value in a tracking mode rather than peak voltage. To set peak amplitudes, select a higher frequency range, set the peaks, then return to the lower frequency range.

D. For dc output operation, the **FREQUENCY RANGE** switch must be at 10K or lower frequency positions to ensure correct amplitude display.

5. **FREQUENCY RANGE (Hz) Switch** — Selects one of the 10 frequency ranges. The range number represents the maximum frequency obtainable for the selected range. Some overranging exists.
6. **SYMMETRY Control** — The large knob selects a right-hand or left-hand waveform time-symmetry. The small **VARIABLE** knob varies the waveform time-symmetry up to 19:1 or 1:19. When these controls are used, the frequency range is divided by approximately ten; however, the readout shows actual output frequency.
7. **DC OFFSET Control** — Adjusts dc base line offset above (+) or below (−) signal ground; or, when DC is

selected on the **WAVEFORM** switch, adjusts dc voltage at the 50Ω output. The large knob selects polarity, and the small **VARIABLE** knob adjusts voltage up to ±10 Vdc into an open circuit (±5 Vdc into 50Ω load).

Peak circuit output is limited to ±15 Vdc into an open circuit (±7.5 Vdc into a 50Ω load). (The **OUTPUT ATTEN (dB)** switch (9) affects dc offset as well as waveform amplitude.)

8. **WAVEFORM Selector** — This selects the waveform that appears at the 50Ω output. The waveforms are sine $\sim$, triangle ∇ , square $\square$, positive going pulse $\text{—} \uparrow \text{—}$, negative going pulse $\text{—} \downarrow \text{—}$, and DC voltage. See Figure 2-2 for phase and polarity relationships.
9. **OUTPUT ATTEN (dB) Control** — The large knob attenuates the 50Ω output from 0 dB (15 V p-p max into 50Ω load) to −60 dB (15 mV p-p into 50Ω) in 20 dB steps. The small **VARIABLE** knob may be used to continuously change the amplitude between the detented steps up to 40 dB. Maximum attenuation is −80 dB (1.5 mV p-p into 50Ω). The **OUTPUT ATTEN (dB) VARIABLE** control is inoperative when DC is selected on the **WAVEFORM** switch.

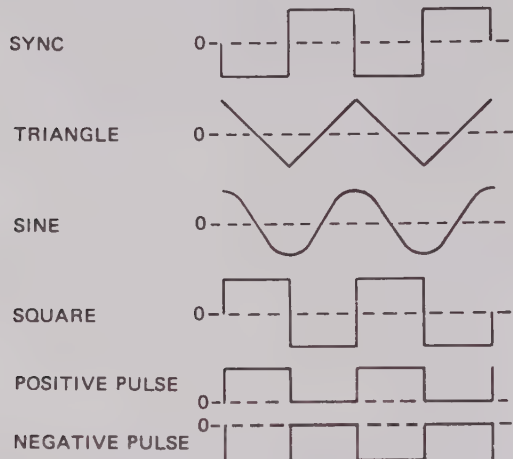


Figure 2-2.

Selectable and Sync Signal Phase and Polarity Relationships

10. **50 Ω OUT** — This is the selected waveform output for the main generator or a dc voltage. The Model 147 operating into an open circuit provides 30 V maximum, or into a 50 Ω load provides a 15 V p-p output. The displayed amplitude is correct for the 50 Ω termination.
 11. **SYNC OUT** — This is a square wave (or rectangular if SYMMETRY control is in use) with the same frequency and opposite polarity of the selectable square wave at the 50 Ω output. Amplitude into an open circuit is greater than 4 V p-p (2 V p-p into 50 Ω). Rise and fall times are less than 50 ns. See Figure 2-2 for phase and polarity relationships.
 12. **SWEEP TIME Control** — When in any of the sweep modes, this control determines the duration of the sweep cycle by controlling the frequency of the sweep generator, which is independent of the frequency of the main generator. The large knob selects the range, which is bounded by the time values printed on the panel on either side of the detent setting. The small VARIABLE knob varies the time throughout the range; when full cw, the sweep time is equal to the time printed to the right of the detent line; rotating the VARIABLE knob ccw increases the sweep time at least by 10:1 and up to 100:1. The full ccw position is not calibrated.
 13. **SWP/GCV OUT** — When the generator is in CONT, TRIG, or GATED mode, this output provides a fixed 0 to nominal +5 V sawtooth. The frequency of this sawtooth is controlled by SWEEP TIME. When the generator is in CONT SWP, TRIG SWP, or SWP & HOLD mode, the output becomes the generator control voltage (GCV) that is proportional to main generator frequency.
- This voltage may be used to drive the X-axis of an oscilloscope in the X-Y mode or the X-axis of an X-Y recorder, thus converting the recording device from the time to the frequency domain.
14. **SWEEP WIDTH Control** — Determines the amount of sweep when in one of the sweep modes by varying the amplitude of the sweep signal.
 15. **TRIG IN** — A dc coupled input with 10 k Ω input impedance. The TRIG LEVEL control adjusts the sensitivity of the generator to this input signal. Sensitivity can be varied to accept signals greater than 1 V to greater than 7.5 V, positive or negative voltage. Maximum voltage is 50 V.
 16. **MODE Switch** — Selects the operating mode of the main generator (50 Ω OUT) as follows:
 - a. **CONT Mode** — The generator operates at the selected frequency and runs continuously. (The SWP/GCV output is a fixed 0 to 5 V ramp in this and the following two modes.)
 - b. **TRIG Mode** — The generator will give one complete cycle of output when the MAN TRIG is pressed or for each pulse applied to TRIG IN. The cycle begins and ends at zero phase, which is zero volts or dc voltage level offset. Since the internal sweep operates independently it can be used to provide a repetitive trigger signal by connecting the SWP/GCV OUT to TRIG IN.
 - c. **GATED Mode** — Operates the same as TRIG MODE except that the generator will continue to have output for the full time that the MAN TRIG switch is held down or the gate signal at TRIG IN exceeds the gating level set by the TRIG LEVEL control.
 - d. **CONT SWP Mode** — The main generator operates continuously and repetitively sweeps from the minimum to maximum frequency as determined by the sweep controls. See Figure 2-3. (In this mode as in the following two sweep modes, SWP/GCV OUT becomes the generator control voltage (GCV) which is proportional to the instantaneous frequency of the generator.)
 - e. **TRIG SWP Mode** — The main generator oscillates at the start or low frequency until a trigger signal

is applied. The frequency then sweeps to the maximum frequency as determined by SWEEP WIDTH and then returns to the low frequency until another trigger is applied. See Figure 2-3.

- f. **SWP & HOLD Mode** — When gated, the generator sweeps to the high frequency and remains at the high frequency for the duration of the gate signal. When the gate falls, the generator returns to the low frequency. See Figure 2-3.

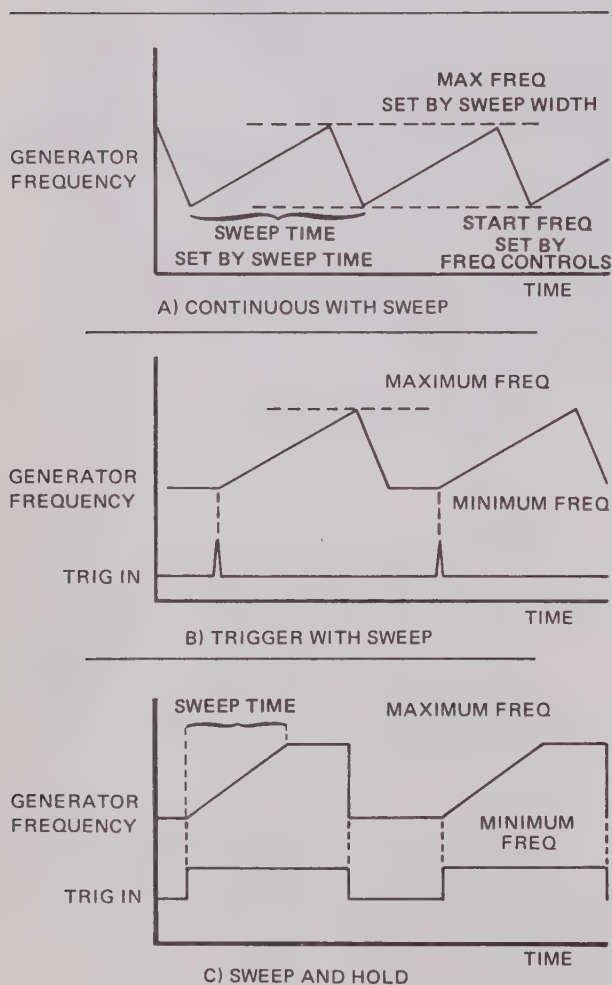


Figure 2-3. Sweep Modes

17. **TRIG LEVEL Control** — Adjusts the sensitivity of the TRIG IN circuitry. When full ccw, approximately -7.5 V or greater negative voltage is required for triggering. In the full cw position, approximately $+7.5$ V or greater positive voltage is required for triggering. Immediately ccw of midpoint, -1 V or greater negative voltage will trigger the instrument. Immediately

cw of midpoint, $+1$ V or greater positive voltage will trigger the instrument. By rotating the knob, it is possible to manually trigger the generator. In the GATED mode, the generator will begin to run continuously as the control is rotated cw past the midpoint. When using the MAN TRIG, this control must be ccw of the midpoint at about 9 o'clock.

18. **MAN TRIG** — When in TRIG mode, pressing this switch causes one cycle of the selected waveform to appear at the 50Ω output. When in GATED mode, the waveform is continuous while the switch is pressed. The TRIG LEVEL control must be ccw from midpoint for proper MAN TRIG operation.
19. **FREQUENCY CONTROL** — A combination coarse and fine control used in conjunction with the FREQUENCY RANGE switch and the display to select the desired frequency. The fine or vernier portion of the FREQUENCY CONTROL covers approximately 30 degrees of knob rotation. After the knob has been rotated through the vernier range, further rotation is in the coarse control range. Reversing the direction of rotation immediately places the knob back in the 30 degrees of vernier range again. The usual procedure is to rotate the knob just past the desired frequency, reverse the direction of rotation, and use the fine control range to accurately select the desired frequency.
20. **VCG IN** — This connector allows external control of frequency. With 0 volts in, the generator frequency (50Ω OUT) is determined by the frequency range selected and the FREQUENCY CONTROL setting and is displayed on the LED readout. A positive VCG voltage will increase this frequency, and a negative voltage will decrease the frequency. Input impedance is $5\text{ k}\Omega$. Restrictions for linear operation are (1) FREQUENCY RANGE selection is the upper frequency and the lower frequency is 1000 times below the FREQUENCY RANGE selection and (2) 5 V is the maximum voltage input. Either restriction may be exceeded for nonlinear operation, but operation is not specified.

2.4 INSTALLATION CHECKS

The following procedures are used to determine that the instrument is operating properly. Field calibration and check-out instructions (to be supplied) are to be used to ensure that the instrument complies with the specifications. If the instrument is not operating properly or within specifications, refer to the warranty on the back of the title page.

Use a Tektronix Model 454 oscilloscope or equivalent when performing these installation checks.

1. After connecting the line cord to the ac line, set the front panel controls and switches as follows:

POWER	In
FREQUENCY RANGE	1K
SYMMETRY	OFF
DC OFFSET	OFF
WAVEFORM	
OUTPUT ATTEN (dB)	0
OUTPUT ATTEN (dB)	
VARIABLE	Fully Clockwise
SWEEP TIME	OFF
MODE	CONT
READOUT FUNCTION FREQ	In

2. Connect the 50 Ω OUT connector with a shielded cable terminated in a 50 ohm load to the oscilloscope and set FREQUENCY CONTROL to obtain a 1 kHz reading on the 147 display.
3. Press the PK AMPL MAX push button. Approximately +7.5 V should be displayed. Press MIN; approximately -7.5 V should be displayed. Observe the oscilloscope and verify the 1 kHz sine wave and peak voltages.
4. Set the OUTPUT ATTEN (dB) VARIABLE control full ccw. Approximately -0.7 V should be displayed. Compare with oscilloscope values.
5. Check minimum and maximum amplitudes of sine  and triangle  waveforms. They should be approximately plus and minus 7.5 V.
6. Check minimum and maximum amplitudes of positive and negative pulse waveforms  and . They should be approximately +0.7 V, 0 V and 0 V, -0.7 V, respectively.
7. Set the OUTPUT ATTEN (dB) VARIABLE control full clockwise and the WAVEFORM switch to  and press the FREQ push button. Adjust the FREQUENCY CONTROL for a 1 kHz readout.
8. Switch the FREQUENCY RANGE control to check range-to-range tracking accuracy. The 147 should read approximately the FREQUENCY RANGE value. Verify the frequencies with the oscilloscope.
9. Select the square waveform and rotate the SYMMETRY switch to  and the VARIABLE control full clockwise. Waveform asymmetry should be approximately 19:1. Rotate the VARIABLE control full ccw; the waveform should be symmetrical. Verify that the other switch position and VARIABLE control give approximately 1:19 waveform asymmetry.

10. Turn the SYMMETRY switch to OFF; press the PK AMPL MAX push button and select DC on the WAVEFORM switch.
11. Set the DC OFFSET switch to + and rotate the VARIABLE control full clockwise. The readout should be approximately +5 V. Verify the reading with the oscilloscope.
12. Set the DC OFFSET switch to -. Readout should be approximately -5 V. Verify the reading with the oscilloscope.
13. Rotate the OUTPUT ATTEN (dB) switch through each position. Verify the attenuation on the oscilloscope. (The VARIABLE control is inoperative for DC.)
14. Turn the DC OFFSET switch to OFF and connect the SWP/GCV OUT to the oscilloscope without a load. With the SWEEP TIME switch set to 10 ms/1 ms and the VARIABLE control set full clockwise (1 ms sweep), verify that the SWP/GCV OUT waveform is approximately a 1 kHz sawtooth. Set the VARIABLE control full ccw. The SWP/GCV OUT waveform should be approximately 100 Hz.
15. Check the SWP/GCV OUT frequency in all positions of the SWEEP TIME switch and at both the cw and ccw ends of the VARIABLE control.
16. Use a shielded cable equipped with BNC connectors to connect SWP/GCV OUT to TRIG IN and connect the oscilloscope to 50 Ω OUT. Set the MODE switch to TRIG, the WAVEFORM switch to  and the SWEEP TIME to 1 s/0.1 s. Rotate the TRIG LEVEL control while observing the oscilloscope. One cycle of the waveform should be displayed each time the sweep output triggers the main generator.
17. Set the MODE switch to GATED and rotate the TRIG LEVEL control while observing the oscilloscope. The multiple cycles of the selected output waveform should appear when the TRIG LEVEL control is rotated full cw and disappear when the control is turned full ccw.
18. This step sets low and high frequencies of the sweep range. Disconnect the cable to TRIG IN. Set the MODE switch to SWP & HOLD, the SWEEP WIDTH control full clockwise, the TRIG LEVEL control to 9 o'clock and the FREQUENCY RANGE switch to 10K. Set the SWEEP TIME switch to 100 s/1 s and the SWEEP TIME VARIABLE control full clockwise. Set the output frequency to 0.1 kHz with the FREQUENCY CONTROL. Rotate the TRIG LEVEL control to 3 o'clock and set the SWEEP WIDTH control

for a 10 kHz readout. Repeat the low and high frequency settings because of interaction. Set the MODE switch to CONT SWP. Set the SWEEP TIME VARIABLE control full ccw. The displayed output should sweep from 100 Hz to 10 kHz.

19. Set the MODE switch to TRIG SWP and press the MAN TRIG switch while observing the oscilloscope. Displayed output should sweep once from 100 Hz to 10 kHz.
20. Connect the SWP/GCV OUT connector to the oscilloscope input without a load. Set the MODE switch to CONT, SWEEP TIME switch to 10 ms/1 ms and the SWEEP TIME VARIABLE control full clockwise. The oscilloscope should display approximately a 1 kHz sawtooth waveform.
21. Set the MODE switch to TRIG and then to GATED. The same 1 kHz sawtooth waveform should be present in these modes.
22. Set the MODE switch to CONT SWP, then TRIG SWP, then SWP & HOLD. The SWP/GCV OUT signal should be a GCV signal proportional to the instantaneous frequency of the main generator.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond the completion of the initial installation checks given in Paragraph 2.4. A one-half hour warm-up period should be allowed for the associated equipment to reach a stabilized operating temperature, and for the Model 147 to attain stated accuracies.

2.5.1 Operation as a Function Generator

1. Properly terminate the 50Ω OUT connector for accurate voltage readings.
2. Select desired output waveform using the WAVEFORM switch.
3. Set MODE switch to CONT.
4. Press the FREQ push button; set the FREQUENCY RANGE switch to the desired range, and set FREQUENCY CONTROL for the desired frequency. (For frequency readout press the READOUT FUNCTION FREQ push button.)
5. Set the OUTPUT ATTEN (dB) switch for the desired output level and amplitude. (For amplitude readout, press the READOUT FUNCTION AMPL MAX or MIN push button.) For reference, Table 2-1 gives the

approximate output amplitude levels at attenuator settings. The output levels of the positive and negative pulse waveforms are one half of these levels.

Table 2-1

Attenuator Position	Peak to Peak Output into 50Ω Load	
	Maximum (variable full cw)	Minimum (variable full ccw)
0 dB	15 V	1.5 V
-20 dB	1.5 V	150 mV
-40 dB	150 mV	15 mV
-60 dB	15 mV	1.5 mV

6. With the DC OFFSET and SYMMETRY controls turned to OFF, the output waveform should be a symmetrical waveform oscillating around a zero dc reference point (except when a positive or negative pulse has been selected).
7. To add dc offset, first set the DC OFFSET control for the polarity of dc offset desired. Next, change the WAVEFORM switch to DC position and, using the readout display, adjust the DC OFFSET VARIABLE control until the desired amount is read on the display. Return the WAVEFORM switch to the selected waveform position. If an excessive amount of dc offset is used, waveform clipping may be observed. The sum of peak waveform voltage and the dc offset cannot exceed the maximum rated output of the generator. For example, on the 0 dB attenuator setting, the maximum output is 15 V peak to peak or 7.5 V peak above and below zero volts. Therefore, offset plus the peak voltage cannot exceed 7.5 V peak. See Figure 2-4.

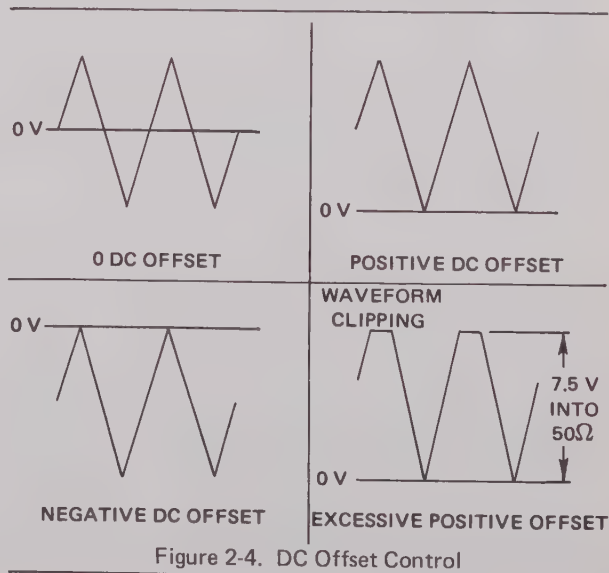


Figure 2-4. DC Offset Control

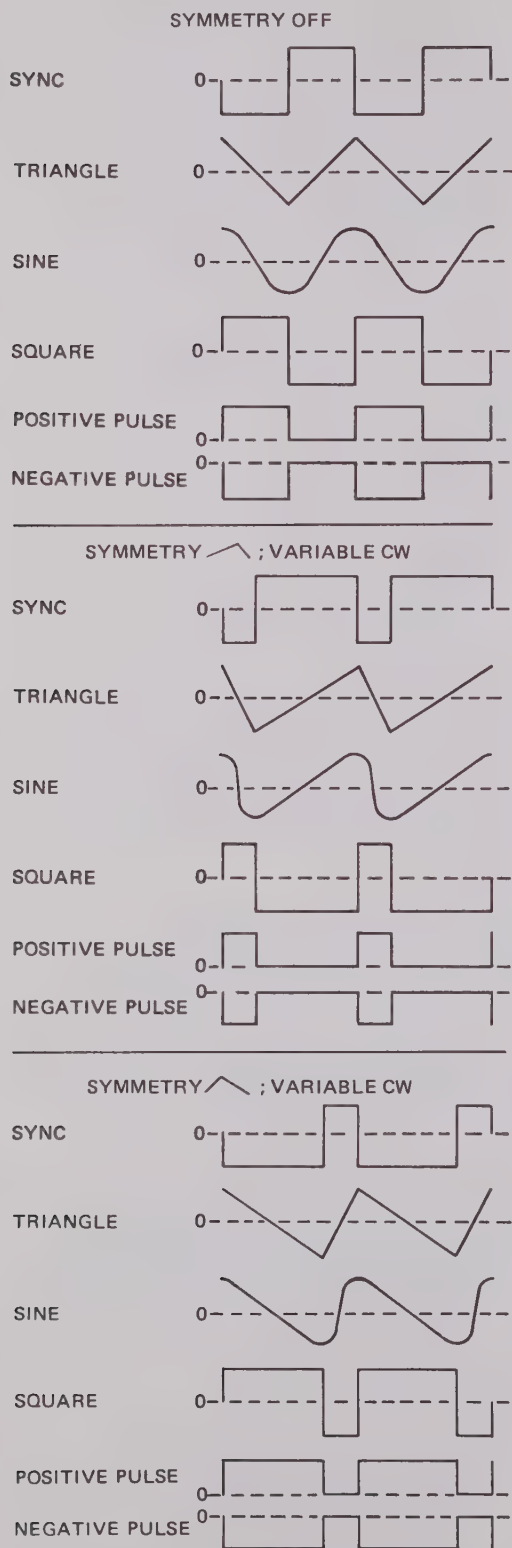


Figure 2-5. Waveform Phasing and Symmetry Control

8. Set SYMMETRY control for desired symmetry or asymmetry. The symmetry control can be used to develop ramp waveforms with variable rise/fall ratios and single or multiple pulses with variable duty cycles. By using the sine wave with asymmetry, controllable sine distortion can be developed. Figure 2-5 shows the effect of this control on output waveforms. The frequency of an asymmetrical waveform will be approximately a factor of 10 lower than the symmetrical waveform frequency output.

2.5.2 Operation as a Voltage Controlled Generator

The VCG input connector can be used to externally control the frequency of the generator. If a positive voltage is applied to the VCG input terminal, the frequency will increase from the FREQUENCY CONTROL setting. A negative voltage will cause the frequency to decrease from the FREQUENCY CONTROL setting.

A 5 V excursion in VCG voltage can vary the frequency up to 1000:1 in each range as follows:

Range	Limits for Linear Operation	
	Lower	Upper
0.01	0.01 mHz	0.01 Hz
0.1	0.1 mHz	0.1 Hz
1	1 mHz	1 Hz
10	10 mHz	10 Hz
100	100 mHz	100 Hz
1K	1 Hz	1 kHz
10K	10 Hz	10 kHz
100K	100 Hz	100 kHz
1M	1 kHz	1 MHz
10M	10 kHz	10 MHz

As shown, the range setting is the upper limit. This limit may be exceeded as there is a 10 to 20% overranging capability; however, overranging will be nonlinear and the operation is unspecified. Operation below the lower limit of any range setting is not recommended.

The nomograph of Figure 2-6 shows the characteristics of the VCG circuit. Column A gives the output frequency without a VCG voltage, Column B, the VCG voltage and Column C, the resultant output frequency of the generator. As an example of VCG operation, the FREQUENCY RANGE was selected as 1 kHz and the FREQUENCY CONTROL set for a 300 Hz readout (see Column A, Figure 2-6). A $+3\frac{1}{2}$ V VCG input (Column B) increased the output frequency (Column C) to 1000 Hz. Remember, on the nomograph, multiply Column A and C by the frequency range; e.g., $0.3 \times 1 \text{ kHz} = 300 \text{ Hz}$. A further increase in VCG voltage would cause nonlinear operation as the range value

of 1 kHz would be exceeded. For 1000:1 frequency decrease, simply decrease the VCG voltage by 5 volts to $-1\frac{1}{2}$ V, as shown, which results in $0.01 \times 100 \text{ Hz}$ or 1 Hz.

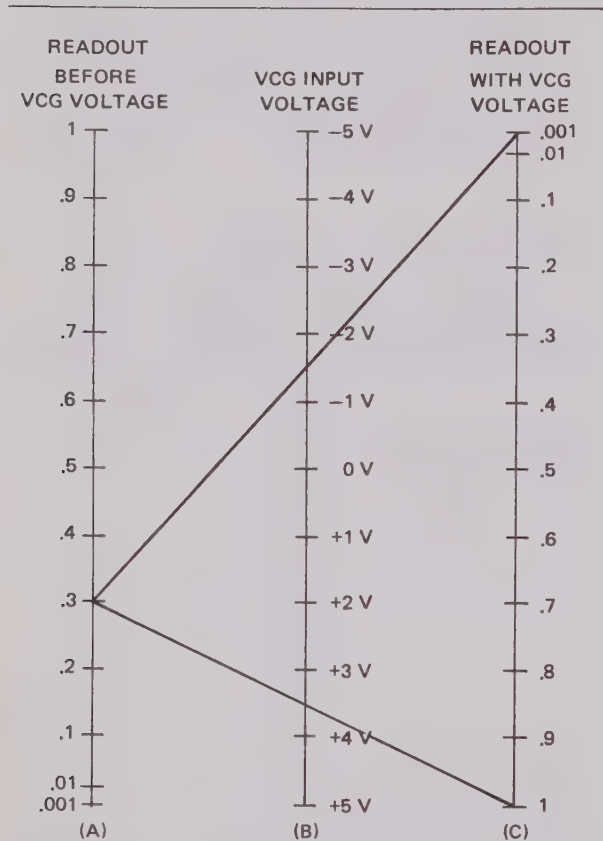


Figure 2-6. VCG Voltage-to-Frequency Nomograph

2.5.3 Operation as a Triggered Generator

1. Adjust the generator as for continuous operation (Paragraph 2.5.1); then set the MODE switch to TRIG.
2. If manual triggering is desired, set the TRIG LEVEL control (small knob) to the 11 o'clock position. For external triggering, set the TRIG LEVEL control to exclude undesirable trigger levels.
3. Operate the MAN TRIG switch or apply a 1 to 50 V signal to the TRIG IN connector.

NOTE

The SWP/GCV output may be used as a repetitive trigger source. In this case, the SWEEP TIME control determines the repetition rate of the triggered output signal.

2.5.4 Gated or Tone Burst Operation

With the generator adjusted as in trigger operation, change the MODE control to GATED position. The generator output will then be a burst of cycles. If the trigger is the SWP/GCV OUT sawtooth waveform, the duration of the burst is adjustable by the TRIG LEVEL control (see Figure 2-7). Notice that the last cycle gated is completed even if the gate signal is removed. In manual gating, the tone burst continues as long as the manual switch is pressed.

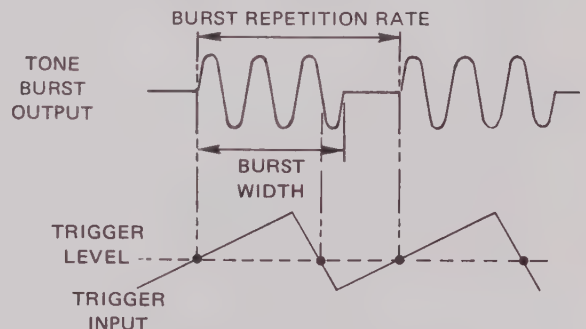


Figure 2-7. Gated Operation

The generator can be made to free run in this mode at certain settings of the trigger level control. By resetting the TRIG LEVEL control, normal gated operation can be re-established.

2.5.5 Operation as a Sweep Generator

The operation of the three sweep modes (continuous with sweep, triggered sweep, and sweep and hold) can be visualized by the graphs in Figure 2-3. Operation consists of proper terminations. Setting the low and high end frequencies, sweep time, signal amplitude and sweep mode. All are covered in the following example.

These modes together with the GCV output can be used to perform frequency response tests and drive an X-Y recorder or oscilloscope for display of the frequency response. As an example, Figure 2-8 shows a circuit under test which is to be swept and the frequency response of the circuit displayed on the oscilloscope. Figure 2-9 shows a similar setup using an X-Y recorder. The following procedure is used to set up the Model 147 as a sweep generator.

1. Terminate the 50Ω output with 50Ω . Setup as in Figure 2-8 or 2-9 except bypass the circuit under test for this setup procedure.
2. Set the MODE switch to SWP & HOLD, the SWEEP TIME switch to OFF, and TRIG LEVEL to 9 o'clock.

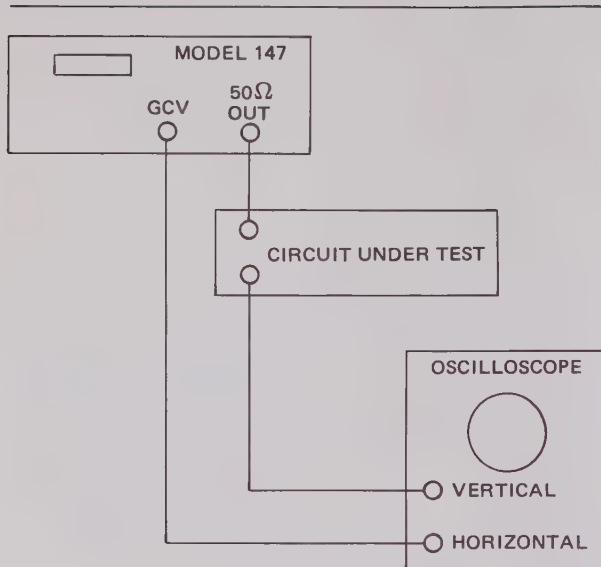


Figure 2-8. Frequency Response Test Using an Oscilloscope in the X-Y Mode

8. With the circuit under test bypassed, and the oscilloscope, if used, in the external horizontal mode, adjust the horizontal position so that the trace is positioned on the left reticle on the screen or chart.
9. Rotate the TRIG LEVEL control to 3 o'clock and adjust the horizontal gain of the oscilloscope or recorder so that the waveform is positioned on the extreme right hand reticle, or any convenient reticle of the screen or chart for proper scaling.
10. Set the SWEEP TIME controls as desired for sweep duration. Sweep fast for the best oscilloscope presentation and sweep slow if the X-Y recorder is used.
11. For continuous sweep rotate the MODE switch to TRIG. For triggered sweep or sweep and hold operation, adjust the TRIG LEVEL control to 9 o'clock for manual triggering or gating, or adjust as desired for external triggering or gating.
12. Insert the circuit to be tested as in Figures 2-8 or 2-9 and observe the frequency response characteristics shown on the oscilloscope or recorder.

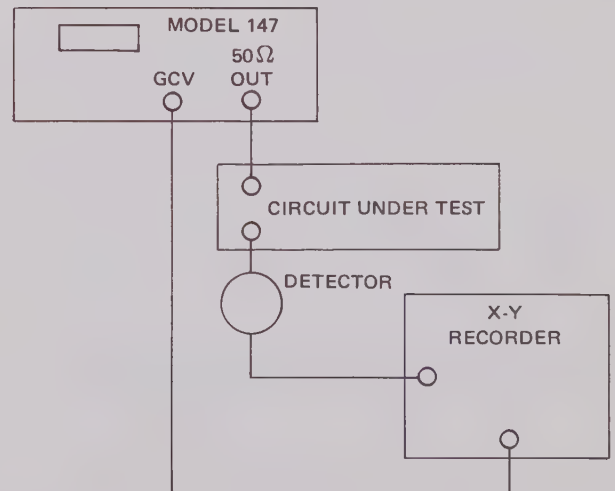


Figure 2-9. Frequency Response Test Using an X-Y Recorder

3. Depress the READOUT FUNCTION FREQ push button and use the FREQUENCY RANGE switch and the FREQUENCY CONTROL switch to obtain the desired low frequency on the display.
4. Set the SWEEP TIME controls for the desired sweep time.
5. Rotate the TRIG LEVEL control to 3 o'clock. The frequency sweeps to the top and holds. Then rotate the SWEEP WIDTH control until the desired top frequency is displayed.
6. Rotate the TRIG LEVEL control back to 9 o'clock and reset the low frequency. Check the top frequency again and return the TRIG LEVEL control back to 9 o'clock.
7. Use the READOUT FUNCTION PK AMPL push buttons and the display and the OUTPUT ATTEN (dB) controls to obtain the desired signal amplitude.

1. Set the controls as follows:

FREQUENCY CONTROL	fully cw
READOUT FUNCTION	FREQ
FREQUENCY RANGE	1K
SYMMETRY	OFF
(SYMMETRY) VARIABLE	fully ccw
DC OFFSET	OFF
(DC OFFSET) VARIABLE	fully ccw
WAVEFORM	△
MODE	CONT
TRIG LEVEL	fully ccw
SWEEP WIDTH	fully ccw
SWEEP TIME	OFF
(SWEEP TIME) VARIABLE	fully ccw
OUTPUT ATTEN	0
(OUTPUT ATTEN) VARIABLE	fully cw
POWER	depressed (on)

2. Allow the Model 147 30 minutes to warm up with its covers on. After warm up, remove the top and bottom covers and proceed with the calibration. No further disassembly is required.

NOTE

Use the Calibration Component Diagrams to locate test points and components.

POWER SUPPLY

Power Supply Regulation

1. Ensure ac power is connected to the instrument. Connect the voltmeter leads to the main board rear connector pin 34 (common) and rear connector pin 32 (+15 V).

NOTE

R11 in Step 2 is not on the component diagram. As you face the front of the Model 147, R11 is on the upper left part of the power supply board.

2. Adjust power supply board R11 for a reading of +15 Vdc ± 20 mV on the voltmeter.

3. Check the voltage at the main board rear connector pin 33 for -15 Vdc ± 50 mV, at pin 36 for +24 Vdc ± 400 mV, at pin 37 for -24 Vdc ± 400 mV, and at pin 38 for +5 Vdc ± 200 mV.

MAIN BOARD

Triangle Amplitude Adjustment

1. Connect the oscilloscope probe (a type W or 1A5 plug-in module should be used with the scope) to the rear WAVEFORM selector wafer yellow wire. Use main board rear connector pin 34 for ground.
2. Adjust the triangle amplitude to plus and minus 1.25 V ± 5 mV using R108 and R97, respectively.

NOTE

Leave the probe on the yellow wire for the remainder of the main board calibration.

Frequency and Time Symmetry Calibration

1. Set FREQUENCY RANGE to 100K, WAVEFORM to □, FREQUENCY CONTROL fully ccw, and adjust R2 for approximately 1/1250 of full scale (80 Hz) and R24 for time symmetry within 1%.
2. Turn FREQUENCY CONTROL to 1/100 of full scale (1 kHz) and adjust R8 for minimum frequency shift while opening and shorting the VCG IN BNC.

NOTE

If Step 2 cannot be accomplished, center R8 and repeat Step 1.

3. Turn FREQUENCY CONTROL fully cw, FREQUENCY RANGE to 1K and adjust time symmetry within 0.1% with R21.
4. Repeat Steps 1 thru 3 as necessary for accurate time symmetry at full scale to 1/1000 of full scale.
5. Turn FREQUENCY CONTROL to fully cw, FREQUENCY RANGE to 100K, and adjust R3 to obtain 105.0 kHz.

6. Set FREQUENCY RANGE to 10M and adjust C38 to obtain an output frequency of 10.50 MHz.
7. Set FREQUENCY RANGE to 1M and adjust C48 to obtain 1.050 MHz at the output.
8. Set FREQUENCY RANGE to 10K and adjust R4 to obtain 10.50 kHz.

NOTE

1.050 in frequency equals 0.952381 in time.

9. Set FREQUENCY RANGE to 1K and adjust R5 to obtain 1.050 kHz.
10. Set FREQUENCY RANGE to 100 and adjust R6 to obtain 105.0 Hz.
11. Set FREQUENCY RANGE to 10 and adjust R45 to obtain 10.50 Hz.
12. Adjust R69 for 0.1% time symmetry.
13. Readjust R45 for optimum frequency on 10, 1, 0.1 and 0.01 on FREQUENCY RANGE selector.
14. Set FREQUENCY RANGE to 10K, FREQUENCY CONTROL to fully cw, and connect counter to SYNC OUT BNC.
15. Adjust R245 to read same frequency on the readout as the counter (10.50 kHz).

Sine Distortion and Amplifier Adjustments

1. Set FREQUENCY RANGE to 1K, FREQUENCY CONTROL to fully cw, and WAVEFORM to .
2. Adjust R35 so that the dc offset of the sine amplifier is zero.
3. Adjust R147, R146 and R150 for minimum sine wave distortion.
4. Set FREQUENCY RANGE to 10K and readjust R147, R146 and R150 for the optimum sine wave.
5. Alternately perform Steps 4 and 5 until the least amount of sine wave distortion is obtained on both ranges (typically 0.14%).
6. Adjust R172 for a 2.5 V p-p ± 5 mV sine wave.
7. Readjust R35 so that the dc offset of the sine wave amplifier is 0 V ± 5 mV.

Square Wave Amplitude Adjustment

1. Set WAVEFORM to .
2. Adjust the square wave amplitude to ± 1.25 V ± 5 mV using R187 and R190.

SWEEP BOARD

Output Amplifier Adjustment

1. With the 50 Ω OUT BNC connected to the oscilloscope using a 50 Ω $\pm 0.1\%$ termination, set FREQUENCY RANGE to 1K, FREQUENCY CONTROL to fully cw, WAVEFORM selector to , OUTPUT ATTEN to 0, and (OUTPUT ATTEN) VARIABLE to fully ccw.
2. Adjust R139 for amplitude symmetry about ground.
3. Set (OUTPUT ATTEN) VARIABLE to fully cw and adjust R146 for 15 V p-p ± 25 mV output amplitude.

High Frequency Response Adjustment

1. Set FREQUENCY RANGE to 10M, FREQUENCY CONTROL to read 1 MHz and WAVEFORM selector to .
2. Adjust C55 for the best square wave, without peaking, at full amplitude with a 50 Ω load.
3. Set WAVEFORM selector to  and FREQUENCY CONTROL to fully cw.
4. Adjust main board C71 to obtain approximately 15 V p-p output amplitude at full amplitude with a 50 Ω load.
5. If clipping occurs as the waveform is varied from 1M to 10M, readjust main board C71 to correct this occurrence.

V-F Converter Calibration

1. Set FREQUENCY RANGE to 1K, FREQUENCY CONTROL to fully cw, and connect the counter to SYNC OUT BNC.
2. Adjust sweep board R119 to read same frequency on the readout as the counter (1.050 kHz).

Amplifier Zero Adjustments

1. Set FREQUENCY RANGE to 10K, FREQUENCY CONTROL to fully cw, and READOUT FUNCTION to PK AMPL MAX.

2. Jumper peak reader input (TP1) to ground (TP2).
3. Adjust R219 for 0 V $\pm$ 1 mV at the output of peak reader (TP3).
4. Adjust R251 for 0 V $\pm$ 1 mV at the summing node of the absolute value circuit output amplifier (TP4).
5. Adjust R236 for 0 V $\pm$ 1 mV at the output of absolute value circuit (TP5).
6. Disconnect the jumper of Step 2.

Absolute Value Circuit

1. Set WAVEFORM selector to DC.
2. Using + DC OFFSET control set the output at 50 Ω OUT BNC (with 50 Ω load) to +5.00 Vdc.
3. Set the readout to +5.00 V with R240.
4. Set DC OFFSET to —. Use (DC OFFSET) VARIABLE to set the output at 50 Ω OUT BNC (with 50 Ω load) to –5.00 Vdc.
5. Set the readout to –5.00 V with R248.
6. Repeat Steps 2 thru 5 as necessary.

Peak Rectifier Calibration

1. Set FREQUENCY RANGE to 1M, FREQUENCY CONTROL to 20 kHz, DC OFFSET to OFF, WAVEFORM selector to , and (OUTPUT ATTEN) VARIABLE to obtain 12 V p-p.
2. Adjust R228 and R221 to set MAX and MIN readouts to equal oscilloscope readings.
3. Set FREQUENCY RANGE to 10M and FREQUENCY CONTROL to fully cw.
4. Adjust C77 and C75 to set MAX and MIN readouts to equal oscilloscope readings.
5. Repeat Steps 1 thru 4 as necessary.

SWEEP/GCV Adjustments

1. Set FREQUENCY RANGE to 1K and connect the oscilloscope to sweep output (TP6).
2. Adjust R23 to set the output to 0 $\pm$ 5 mV.
3. Set SWEEP TIME selector to 100 ms/10 ms and (SWEEP TIME) VARIABLE to fully cw.

4. Adjust R44 to set the lower peak of the sawtooth wave for 0 V (+0, –5 mV) and R47 to set the upper peak of the sawtooth wave for +5 V $\pm$ 20 mV at the SWP/GCV OUT connector (unloaded).
5. Check for less than 100 mV shift of the lower peak of the sawtooth between 10 ms/1 ms and 100 ms/10 ms ranges.
6. Set MODE selector to CONT SWP, SWEEP TIME selector to OFF and FREQUENCY CONTROL to 1.000 kHz.
7. Adjust R5 to obtain +5 V $\pm$ 50 mV at SWP/GCV OUT connector.
8. Reset R23 to assure at least 1000:1 operation in the SWP & HOLD MODE.

MAIN BOARD

Trigger Baseline Adjustment

1. Set MODE selector to TRIG, FREQUENCY RANGE to 10K, FREQUENCY CONTROL to fully cw, DC OFFSET to OFF, WAVEFORM to , OUTPUT ATTEN to 0, and (OUTPUT ATTEN) VARIABLE to fully cw.
2. Adjust R91 for 0 V $\pm$ 5 mV at 50 Ω OUT BNC (loaded with 50 Ω).
3. Set FREQUENCY CONTROL to fully ccw and adjust R61 to set baseline to 0 V $\pm$ 5 mV.
4. Check that the baseline should remain within $\pm$ 50 mV at all frequency settings.

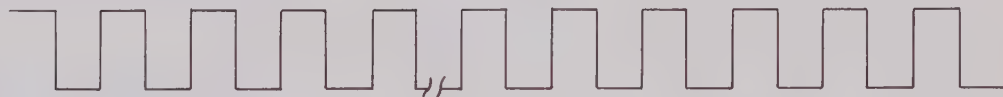
Symmetry Adjustment

1. Set FREQUENCY RANGE to 1K, MODE to CONT, FREQUENCY CONTROL to fully cw.
2. Adjust R19 for 1/10 of reading from SYMMETRY switch OFF to SYMMETRY switch  or .

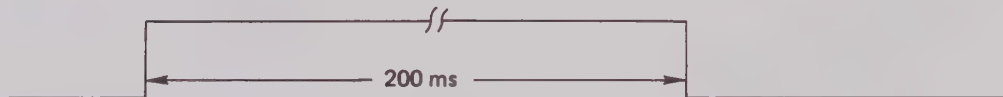
Readout Zero Flicker Adjustment

1. Set SYMMETRY switch to OFF, FREQUENCY CONTROL to fully ccw.
2. Adjust R203 until no flicker is seen in the blanked out decimal points and zeros.

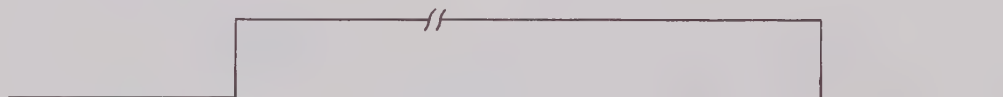
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100 Hz



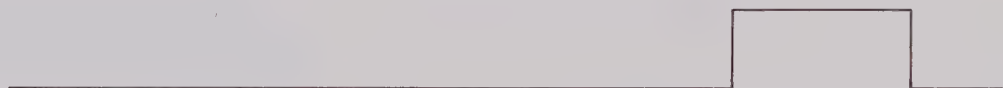
IC25 pin 5



IC26 pin 5



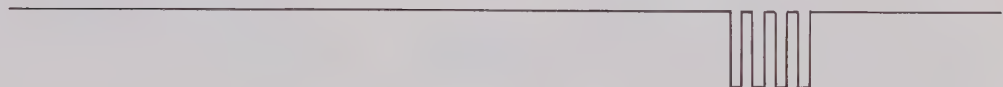
IC26 pin 3



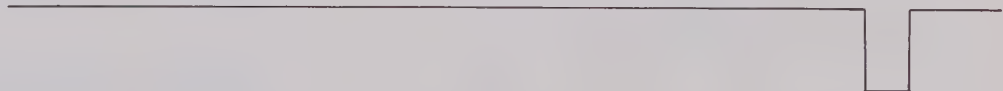
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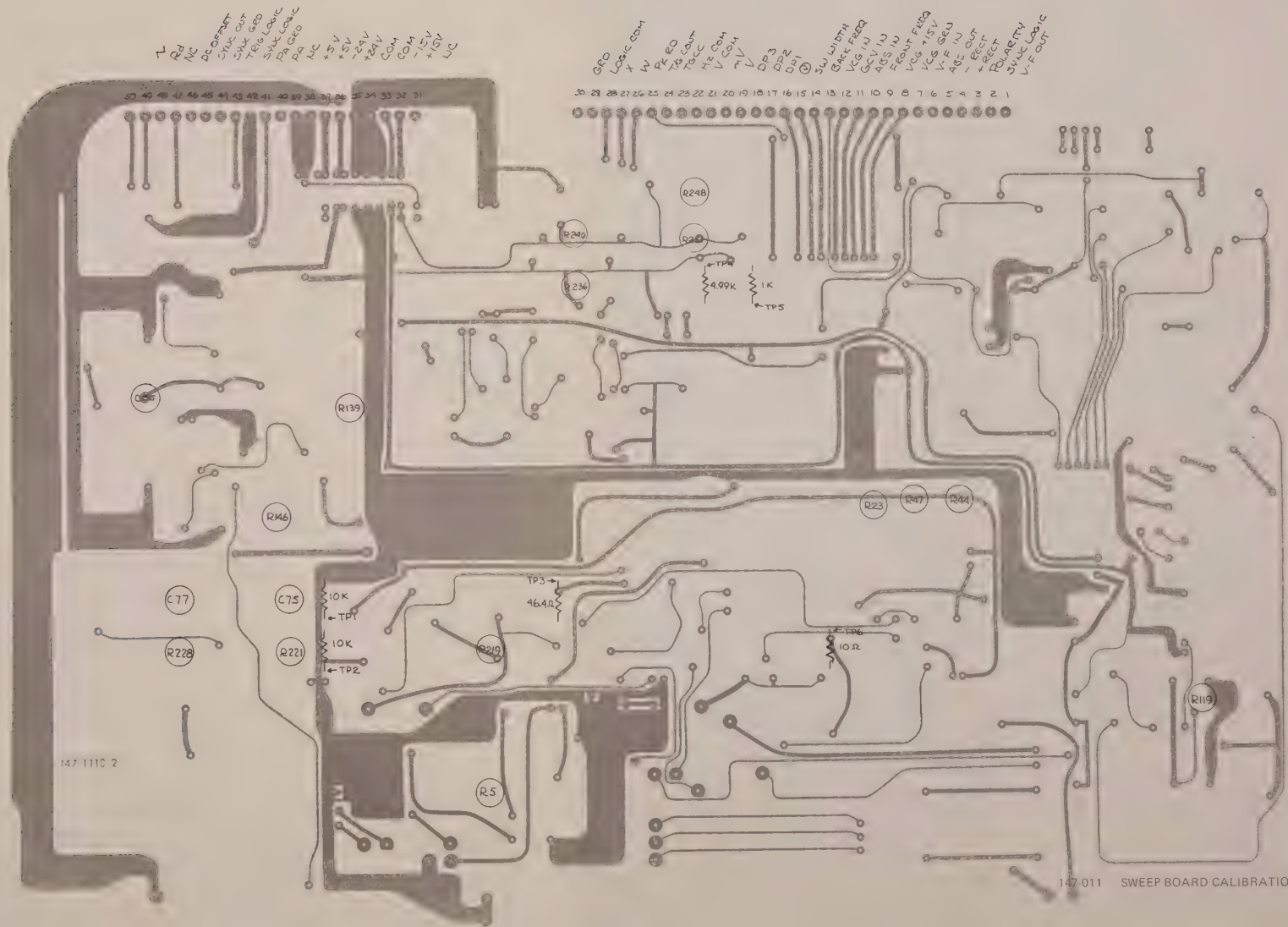
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ADVANCE



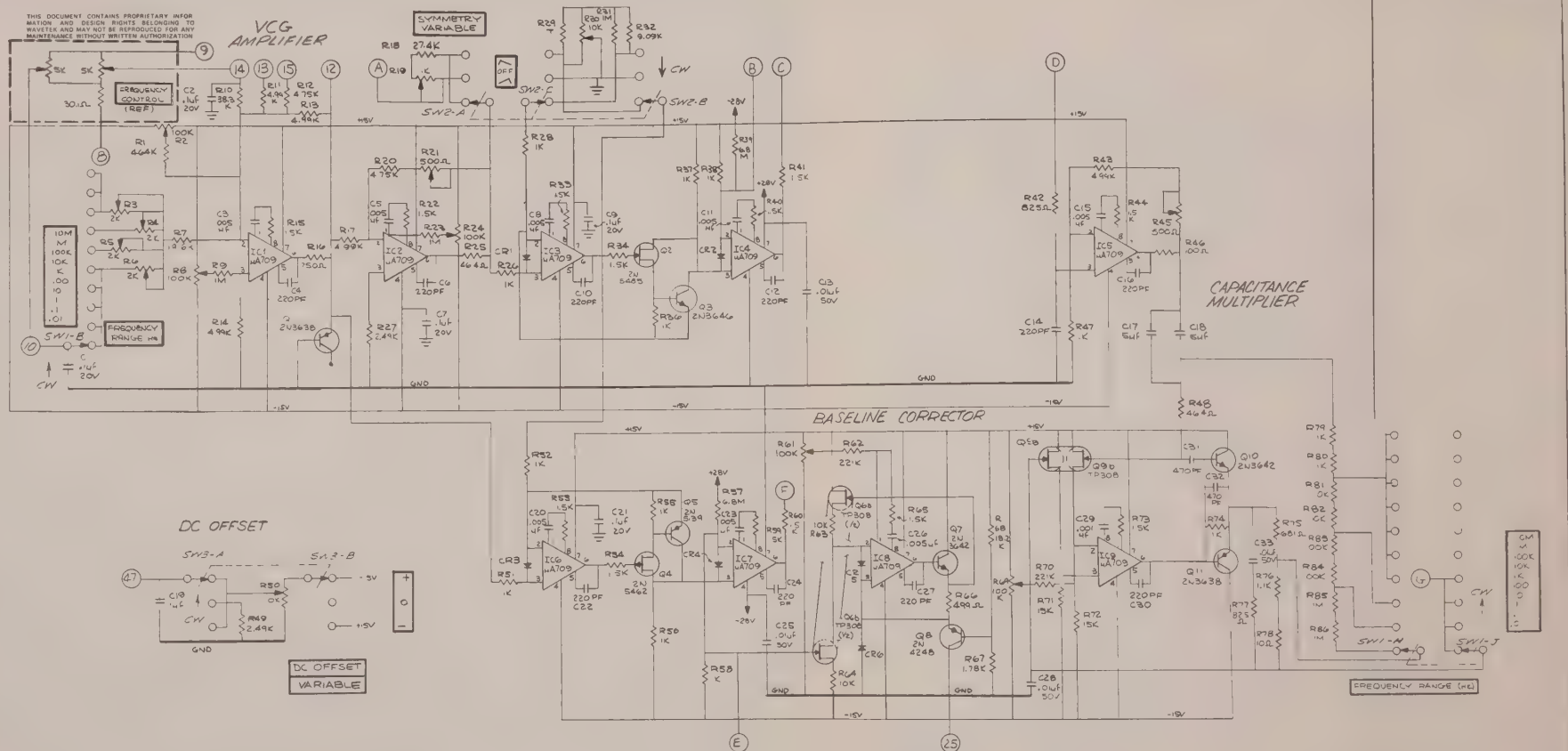
IC23 - 11
RESET



COUNTER CONTROL TIMING DIAGRAM



THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION AND DESIGN RIGHTS BELONGING TO WAVETEK AND MAY NOT BE REPRODUCED FOR ANY MAINTENANCE WITHOUT WRITTEN AUTHORIZATION



5) RESISTORS ARE $\frac{1}{8}$ W 1% METALFILM

4) DIODES ARE FD666G

3) LETTERS IN $\bigcirc$ DENOTE INTERCONNECTIONS BETWEEN SHEETS OF THIS SCHEMATIC

2) NUMBERS IN $\bigcirc$ DENOTE PIN NOS ON REAR CONNECTOR (BETWEEN BOARDS)

1) DESCRIPTIONS IN $\square$ DENOTE FRONT PANEL NOMENCLATURE

NOTE: UNLESS OTHERWISE SPECIFIED

LAST DESIGNATOR USED

CAPACITORS - C115 NOT USED C59, C87

DIODES - CR42 " "

$\pm 0.1\%$ - IC81 " "

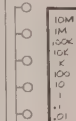
TRANSISTORS - Q63 " "

RESISTORS - R253 " "

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DO NOT SCALE DIMS	SCALE: 1					
DATE	11/25					
TOLERANCE UNLESS OTHERWISE SPECIFIED						
KΩ FOR ANGLES 1						
DO NOT SCALE DIMS						
SCALE: 1						
MODEL NO	147					
DWG NO	D147-210					
REV						
PAGE	23338					
SHEET	1					

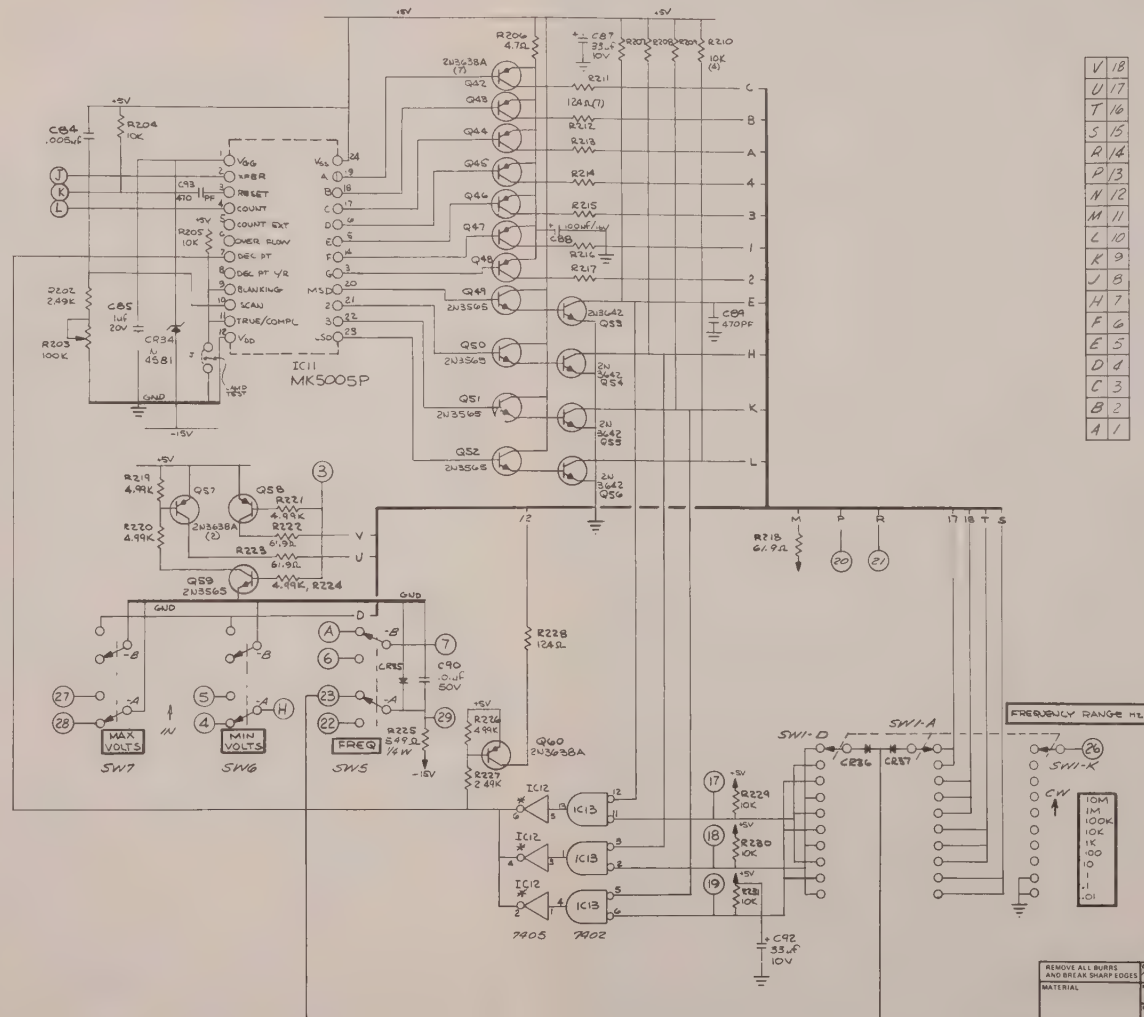
WAVETEK SAN DIEGO - CALIFORNIA

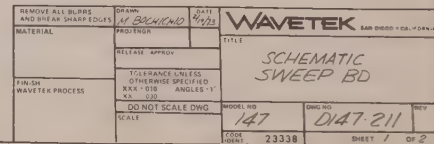
SCHEMATIC
MAIN BOARD





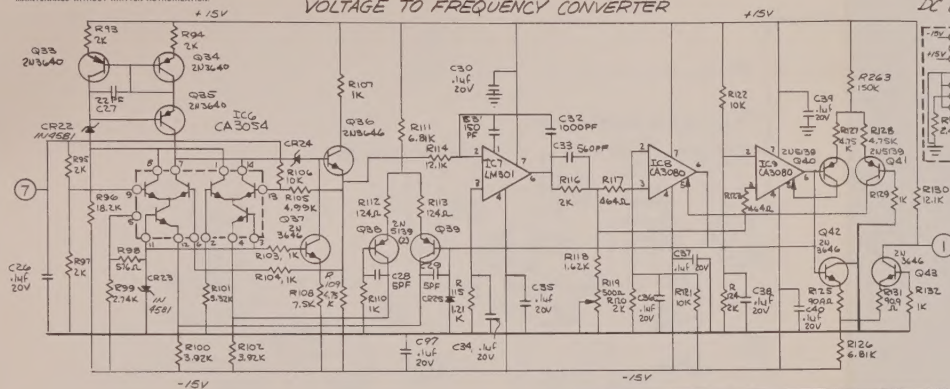
REMOVE ALL BURR AND BREAK SHARP EDGES	DATE 11/20/2014	 SAN DIEGO • CALIFORNIA	
MATERIAL	PROJ ENGR	TITLE	
	REVISION APPROV	SCHEMATIC MAIN BOARD	
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± 0.10 ANGLES ± 1° X.X = 0.00		
FIND WAVETEK PROCESS	DO NOT SCALE DWG	MODEL NO.	REV
	SCALE	147	0147-210
	COSH	23338	SHEET # OF



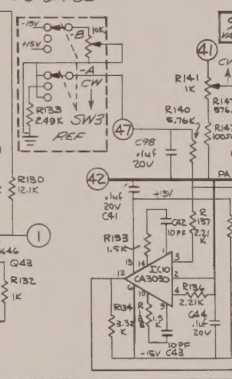


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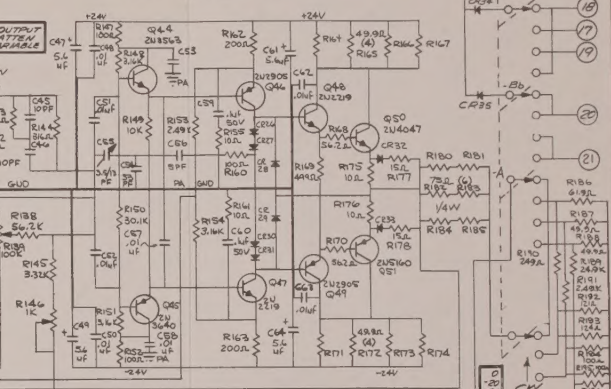
VOLTAGE TO FREQUENCY CONVERTER

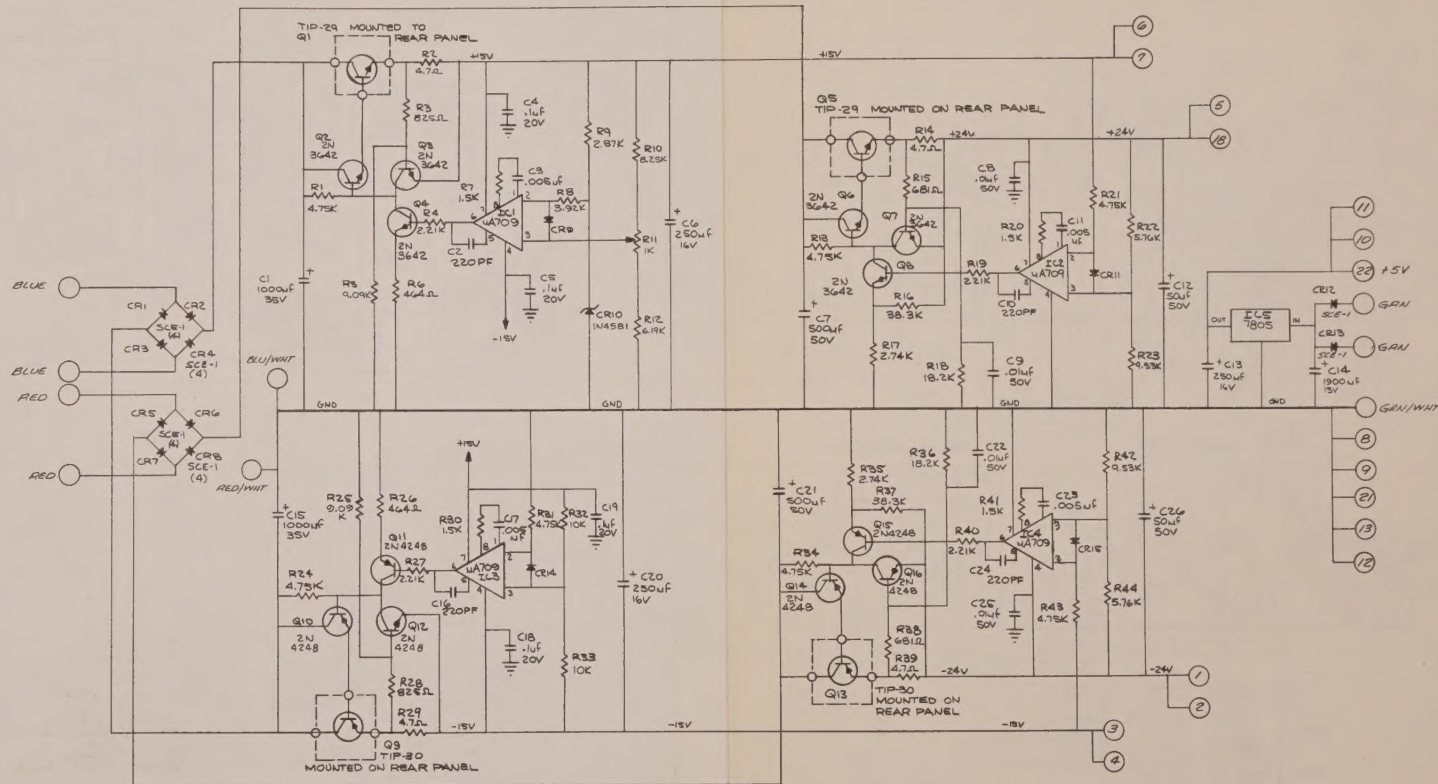


DC OFFSET



OUTPUT AMPLIFIER





3. NUMBERS IN $\bigcirc$ DENOTES PIN NOS ON REAR CONNECTOR (BETWEEN BOARDS)

2. RESISTORS ARE 1/8W, 1%, METAL FILM

1. ALL DIODES ARE FD666

NOTE: UNLESS OTHERWISE SPECIFIED

CAPACITOR - C26
DIODE - CR15
IC - IC15
TRANSISTOR - Q16
RESISTOR - R44

REMOVE ALL BURRS AND BREAK SHARP EDGES	DESIGN BY	DATE	WAVETEK SAN DIEGO - CALIFORNIA
	AT BOKHEND	3/8/79	
MATERIAL	DESIGNER		TITLE
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED		SCHEMATIC POWER SUPPLY
	XX - 0.10 ANGLES 1:1		
	DO NOT SCALE DWG		
	SCALE		
	MODEL NO	D147-212	REV
	147		
	23338		

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